STELLAR VARIABILITY IN THE LOWER PART OF THE CLASSICAL INSTABILITY STRIP

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Abstract. The photometric properties of the variable stars located in the lower part of the classical instability strip are discussed. The importance of the determination of some light curve parameters and their connection with the stellar models are stressed, with a particular emphasis on large amplitude δ Sct stars.

1. Introduction

The lower part of the classical instability strip and the surrounding main sequence are populated by a large variety of pulsating variable stars. In the past years a great effort was made by the stellar astronomers of Brera Observatory (E. Antonello, M. Bossi, L. Mantegazza, E. Poretti, F. Zerbi) to collect a large amount of photometric and spectroscopic data on selected targets in order to improve stellar models. Observations were carried out using the telescopes located in Merate (0.50 m and 1.02 m; a third telescope having a diameter of 1.32 m will be newly available in 1998 after the mirror installation) and at La Silla (European Southern Observatory, Chile, where we use the 0.50 m, 0.90 m, 1.0 m, and 1.4 m telescopes). In this paper we briefly review the results obtained, with a particular emphasis on photometric ones, since the current development of observational techniques renders them within reach of well–equipped amateur astronomers.

2. δ Sct stars

The δ Sct class (DSCT in the GCVS notation) now contains most of the stars previously classified as δ Sct, SX Phe, AI Vel, and RR variables. The only discrimination now maintained is between Population I (i.e. DSCT stars) and Population II (i.e. SXPHE stars). The amplitude of the light variation is not considered a physical discriminant and hence both large (up to 0.50 mag) and small (down to the mmag level) amplitude pulsators are included in the DSCT class. For sake of clarity, let us consider separately the two subclasses.

2.1. Large amplitude δ Sct stars

Most of these variable stars are single–periodic, showing light curves significatively deviating from a pure sinusoid. In such a case it is possible to fit the measurements by a sum of cosine functions having frequencies $f, 2f, 3f$, etc.

(Fourier decomposition) and then to study the particularities of the phase and amplitude parameters (see Pardo & Poretti 1997 and references therein for the application of this technique to Cepheid light curves). The particularities of the Fourier parameters of the δ Sct light curves were reviewed by Poretti et al. (1990). Accurate photoelectric photometry is available for all the single–periodic stars brighter than $V = 10$. CCD photometry of faint objects is highly desirable in order to increase the sample and to have a better definition of the properties of the Fourier parameters. In particular, it is important to confirm the bimodal distribution of the amplitude ratio $R_{21} = A_{2f}/A_f$ and to verify if it is possible to ascribe it to a resonance effect. Moreover, the phase parameter $\phi_{21} = \phi_{2f} - \phi_f$ has been recognized as a powerful pulsation mode discriminant and therefore to verify if all the large amplitude DSCT stars are really fundamental radial mode pulsators, or if overtone pulsators can be found among them. We recall here the case of V356 Aur (Poretti at al. 1987) and AI Vel (Walraven et al. 1992), clearly indicating that multiperiodicity can be observed and hence other modes than the fundamental can be excited.

In the figure two representative cases are presented. In the left half of the figure, the light curves of V798 Cyg are shown. The first period (upper panel) shows a rising branch covering more than half period, owing to a bump clearly visible just after the minimum light. This kind of asymmetry is quite uncommon in pulsating star light curves as discussed by Poretti & Antonello (1988). Regarding preliminary results described here, it should be noted that the new CCD measurements confirm not only the existence of a second term, but also that its frequency is 6.41 c d^{-1}. This means that f_1/f_2=0.80, as happens for the other star showing the same asymmetrical light curve, i.e. V1719 Cyg. The possible link between the double–mode pulsation and asymmetrical light curve deserves further attention in the near future. In the right half of the figure, the spectacular light curve of the 17th mag star V831 Tau is presented. The amplitude is about 0.70 mag and since the period is 92 min, the ascending branch is only 20 min long!

2.2. Small amplitude δ Sct stars

In the small amplitude δ Sct stars we see the reverse case with respect to the large amplitude stars. Multiperiodicity is quite common and monoperiodicity is rare. When the star is multiperiodic, it is very complicated to make out the power spectrum owing to the interaction between the excited modes and the spectral window. If measurements are performed from a single site, not only the excited frequency f_1 will be detected, but also its aliases $f_1 \pm n$ (where n is an integral number of c d^{-1}). When several frequencies are simultaneously excited, it is not an easy task to correctly separate the true frequencies from the aliases owing to the large number of peaks visible in the power spectra. To simplify the analysis and to proceed to an identification of a large number of excited modes – *asteroseismology* – it is necessary to deal with a better spectral window, and this can be ensured by multisite observations, i.e. carried out at different longitudes. In the case of a monoperiodic star, single–site measurements can provide a very useful check of the constancy of the period (see Riboni et al. 1994 for the case of β Cas), but also the amplitude needs to be monitored (Poretti et al. 1996).

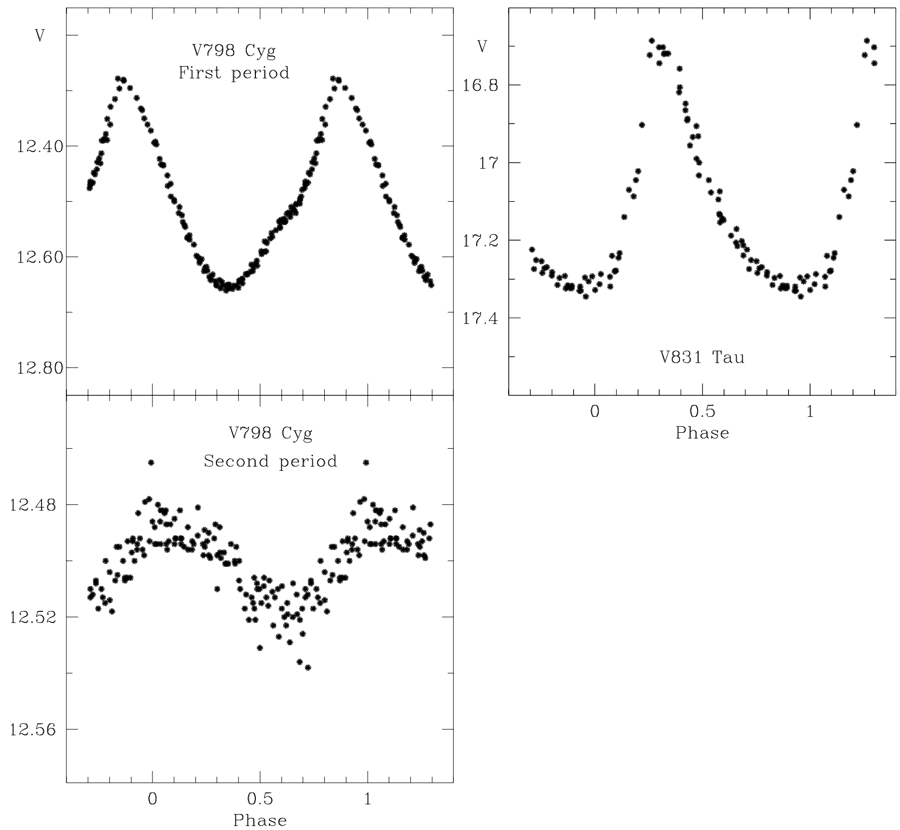

Figure 1. CCD photometry of large amplitude δ Sct stars. Left side: the two periods observed in the light curve of V798 Cyg. Note the steeper descending branch of the first period (upper panel) and the small amplitude sinusoid of the second period (lower panel). Right side: the monoperiodic star V831 Tau shows a very large amplitude and a short period (0.0643 d), making its light increase a spectacular phenomenon.

3. γ Dor stars

In recent years a few early F–type stars showing small amplitude light variations (a few hundredths of a mag) have been discovered, mainly because these stars were used as comparison stars to measure δ Sct stars. Since multiperiodicity is currently observed (Balona et al. 1994; Poretti et al. 1997; Zerbi et al. 1997), $g-$mode nonradial pulsations are the most plausible cause of the variation. The existence of a such a class of pulsating variable stars of spectral type $\sim$F0 is now accepted and γ Dor has been designated its prototype. The study of the light and line profile variations will supply further support to the mode discrimination by studying relationships between the phases of different curves (light, colour, radial velocity, equivalent width, etc.). Powerful techniques have been recently developed to this end and applied by us to the study of p–mode pulsators, i.e. the small amplitude δ Sct stars (Mantegazza et al. 1994, 1996).

4. Conclusions

This rapid excursus among the photometric properties of the pulsators located in the lower part of the instability strip discloses the possibilities offered by the study of accurate light curves. Since well–equipped amateur astronomers can achieve the required accuracy, they can profitably contribute to the knowledge of stellar pulsation. This possibility should not be disregarded by the AAVSO members, also considering the tendency of the big observatories to close the small telescopes. In the near future, the collaboration of amateur astronomers in the multisite campaigns will be more and more requested by professional researchers.

References

Balona L., Krisciunas K., Cousins A.W.J., 1994, MNRAS, 270, 905

Mantegazza L., Poretti E., Bossi M., 1994, A&A, 287, 95

Mantegazza L., Poretti E., Bossi M., 1996, A&A, 312, 855

Pardo I., Poretti, E. 1997, A&A, in press

Poretti E., Antonello E., 1988, A&A, 199, 191

Poretti E., Antonello E., LeBorgne J.F. 1990, A&A, 228, 350

Poretti E., Koen C., Martinez P., Breuer P., de Alwis D., Haupt H., 1997, MNRAS, in press

Poretti E., Mantegazza L., Antonello E., 1987, A&A, 181, 273

Poretti E., Mantegazza L., Bossi M., 1996, A&A, 312, 912

Riboni E., Poretti E., Galli G., 1994, A&A Suppl., 108, 55

Walraven Th., Walraven J., Balona L., 1992, MNRAS, 254, 59

Zerbi F., Garrido R., Rodriguez E., Krisciunas K., Crowe R.A., Roberts M., Guinan E.F., McCook G.P., Sperauskas J., Griffin R.F., Luedeke K.D., 1997, MNRAS, in press